REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE March 1, 1999	3. REPORT TYPE AND DATES COVERED Final Report

4. TITLE AND SUBTITLE
Polarimetric Measurements of Natural Surfaces at Millimeter Wavelengths

5. FUNDING NUMBERS
DAAH04-96-1-0043

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U. S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
ARO 34080.1-EL

11. SUPPLEMENTARY NOTES
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12 a. DISTRIBUTION / AVAILABILITY STATEMENT
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12 b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

In support of the goals the Army Research Office (ARO) and to further scientific understanding, the Microwave Remote Sensing Laboratory at the University of Massachusetts has developed millimeter-wave radars capable of measuring polarimetric scattering from natural surfaces including snow cover. These radars, operating at 35, 95, and 225 GHz, have been employed with two goals in mind. The first has been to develop a database of millimeter-

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OR REPORT	18. SECURITY CLASSIFICATION ON THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

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Polarimetric Measurments of Natural Surfaces at Millimeter Wavelengths

Final Report

Jeffrey M. Baker
Robert E. McIntosh

March 1, 1999

U.S. Army Research Office

DAAH04-96-1-0043

University of Massachusetts

Statement of Problem

In support of the goals the Army Research Office (ARO) and to further scientific understanding, the Microwave Remote Sensing Laboratory at the University of Massachusetts has developed millimeter-wave radars capable of measuring polarimetric scattering from natural surfaces including snow cover. These radars, operating at 35, 95, and 225 GHz, have been employed with two goals in mind. The first has been to develop a database of millimeter-wave scattering measurements. The second goal was to increase the depth of scientific knowledge pertaining to electromagnetic scattering from terrain at millimeter wavelengths. This grant has supported me and other MIRSL researchers in our endeavors to achieve the aforementioned goals.

Summary of Results

The millimeter-wave program at MIRSL began in the 1987 with the construction and field tests of a 35 GHz stepped-frequency and 215 GHz pulsed radar. In 1989, a 225 GHz fully-polarimetric radar was added to the instrument complement, and a 95 GHz polarimeter soon followed in 1991. These radars were used to make some of the first polarimetric measurements of snow cover at these frequencies. Significant results from these experiments can be found in [1]. Other snow cover measurements made under ARO grants can be found in [2] and [3].

The first measurement campaign undertaken during the period of this grant occurred between January and March of 1997. During this period electromagnetic scatter, specifically forward-scatter normalized radar cross section (NRCS), σ^o, from various types of snow was recorded simultaneously at 35, and 225 GHz at incidence angles greater than 80 degrees. In addition to NRCS, Mueller matrices were also measured. *In-situ* data was collected concurrently with the radar measurements to characterize conditions in the snow pack for later comparison with the radar data.

During the months of May and September of 1997, forward-scatter NRCS of asphalt and grass was recorded. *In-situ* data was also collected to paramterize the terrains. These measurements are presented in [4] and [5].

Several significant experimental improvements compared with past efforts were made for this measurement campaign including:

- The addition of a fully polarimetric pulsed 35 GHz radar.
- Simultaneous measurements of forward-scatter at two widely spaced frequencies, 35, and 225 GHz.
- A novel measurement configuration was employed to measure forward-scatter using monostatic radars.

Radar and ground truth data from the measurement campaign has most recently been used to compare measurements to an existing integral equation model with great success. Also, a method of determining the ratio of and

separating the diffuse and specular components of scatter was employed on the collected data. Final results of these analyses will be presented in [6].

List of Publications

[1] Mead, James B., Chang, Paul S., Lohmeier, Stephen P., Langlois, Philip M., and McIntosh, Robert E. Polarimetric observations and theory of millimeter-wave backscatter from snow cover. *IEEE Transactions on Geoscience and Remote Sensing*, 41(1):38–46, January 1993.

[2] Chang, Paul S. *Observations and Theory of Polarimetric Backscatter From Snowcover at 35, 95, and 225 GHz.* PhD thesis, University of Massachusetts, Amherst, MA, May 1994.

[3] Lohmeier, Stephen P., Baker, Jeffrey M., Mead, James B., and McIntosh, Robert E. Simultaneous 35, 95, and 225 GHz fully polarimetric measurements of fallen snow. *Proceedings of IGARSS'95, Florence, Italy*, 1995.

[4] Baker, Jeffrey M., Mead, James B., and McIntosh, Robert E. Forward Scatter Polarimetric Measurements of Terrain at 35 and 225 GHz. *Proceedings of IGARSS'98, Seattle, WA*, 1998.

[5] Baker, Jeffrey M., Mead, James B., and McIntosh, Robert E. Forward Scatter Polarimetric Measurements of Terrain at Millimeter Wavelengths. *IEEE Transactions on Antennas and Propagation*, In Submission

[6] Baker, J. M. "Forward Scatter Polarimetric Measurements of Terrain at 35 and 225 GHz." Ph.D. Dissertation. University of Massachusetts, 1998.

Participating Scientific Personnel and Advanced Degrees Earned

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